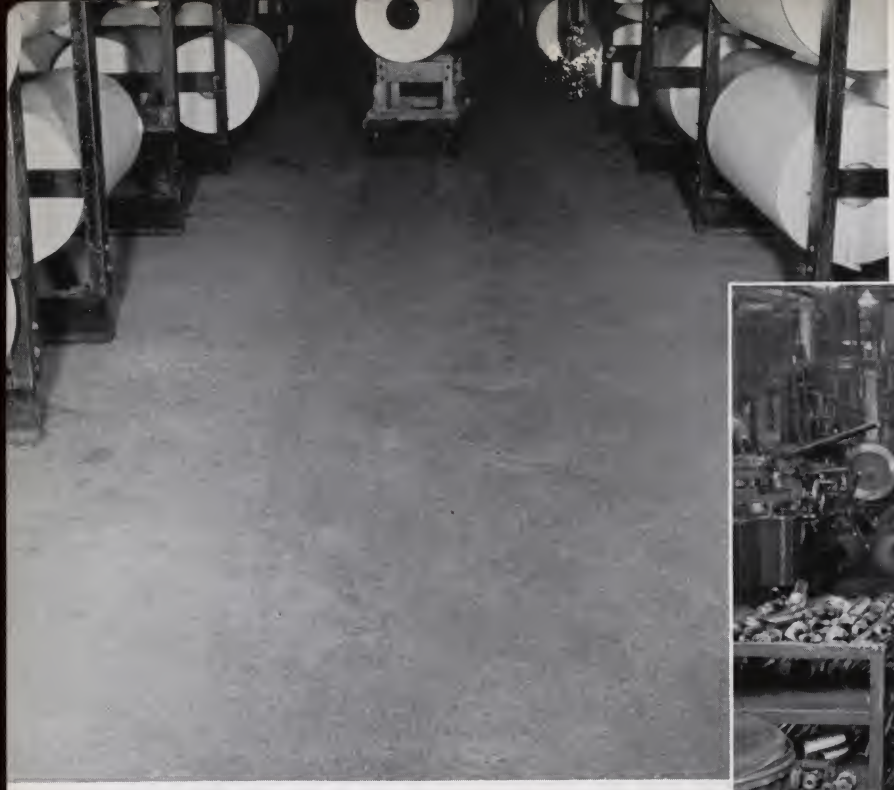
Concrete Floor Finishes

14 YEARS OF SEVERE SERVICE
Trucks loaded with tin plate and other heavy materials have not damaged this concrete floor in continual use for 14 years at Continental Can Co., St. Louis, Mo.



AFTER 20 YEARS—This concrete floor in the trucking aisle of a paper storage room at Eastman Kodak Co., Rochester, N. Y. after 20 years is giving the same excellent service as when new.

11 YEARS OF REAL PUNISHMENT—For 11 years this concrete floor has been used for heavy trucking at Tool Steel Gear and Pinion Co., Cincinnati, Ohio. The owner reports, " . . . we find that it is holding up 100 per cent . . ."

AFTER 25 YEARS—Millions of feet and thousands of loaded trucks have passed over this concrete floor of a platform at Grand Central Terminal in New York City since it was built 25 years ago.

FOREWORD

ARCHITECTS and engineers want to specify and obtain the best concrete floor for a given type of service. The contractor's desire is to build exactly what the plans and specifications call for. Certainly the owner is entitled to a floor that will meet the hard use any floor always receives.

Within the covers of this booklet have been brought together the results of years of laboratory research on proper methods of making and placing concrete for floor use. These laboratory data have been proved on actual concrete floor construction and found to be reliable under service conditions whether for light or heavy duty. Special sections are devoted to the most ornamental and colorful of all floors—those of colored concrete.

The information will tell the owner how to get what he needs—it will assist the architect and specification writer in preparing their plans—it will show the contractor how to build serviceable and durable concrete floors economically.

Portland Cement Association

CONCRETE FLOOR FINISHES

Careful selection of materials!
Skilled supervision!
Workmanship!

THESE are the ingredients of which good floor surfaces are made! The "goodness" will be in direct proportion to the efforts expended by the architect, engineer and contractor in making certain that all three above essentials—not any one—are maintained throughout the construction of the whole job. The top surfaces of floors take the wear and grind. For that reason they deserve all the attention possible during construction. If this is properly done, concrete floors will resist extremely severe conditions indefinitely and "dusting"—that most troublesome of floor diseases—will be unknown. Properly made wearing surfaces is the subject of this book.

The structural slab which carries the surface is discussed only to the extent of showing its relation to the wearing course. Too often floors are specified to be given a "cement finish". Then follow inadequate requirements as to materials or procedure to be followed during construction. Then, the inevitable sequence—trouble.

There are certain basic principles of concrete making which every user of concrete should understand. Because of the thinness of floor finish and the nature of its service, it is particularly important to observe these principles. A different manipulation or working of the concrete into place is used in making floor finishes than in other parts of the structure. It is important that directions for doing this be observed carefully.

AFTER 25 YEARS—Trucks loaded with metal castings have been run over this concrete trucking aisle in the plant of the Stanley Works at New Britain, Conn. for 25 years.

Fundamentals of Concrete Making

Concrete can be made to have a wide range of qualities. Thus, the strength, resistance to wear, watertightness and other characteristics may be varied by changes in the materials or the proportions of the ingredients used and by differences in the manipulation of the concrete.

The quality of the materials affects the quality of the concrete. Portland cement is made to meet standard specifications. It should be protected from moisture while in storage to prevent deterioration. Water used for mixing should be clean. Clean, hard, tough, suitably graded aggregates give more wear-resistant concrete than materials which are inferior in these respects.

The less water used in mixing concrete, the stronger, more wear-resistant and more watertight it will be, providing the concrete can be placed properly.

For uniform concrete, a mixture that does not permit segregation of the ingredients must be used. The proportions of the various sizes of aggregate and aggregate to cement and water should therefore be such as to prevent their separation during handling and placing.

The chemical combination of cement and water to

produce hard, strong concrete requires time. During this time moisture must be available, either by preventing evaporation of the water used in mixing or by replacing that which does evaporate.

Applying these basic principles to concrete floor finishes, the following requirements should be observed:

1. Use only suitable materials.
2. Use not more than 4½ to 5 gal. of mixing water per sack of cement. This includes water introduced as surface moisture on the aggregates.
3. Use mixtures and construction methods which will not permit segregation resulting in free water and fine material on the top surface.
4. Prevent early evaporation of water by keeping the concrete wet as long as practicable.

The aggregates constitute such a large proportion of the concrete volume and have so much influence in producing wear-resistance that they are of first importance.

Aggregates for Floor Finish

Since the aggregates in the wearing course are subject to abrasion, they should be of sufficient toughness and hardness to resist that abrasion. Where conditions are severe, traprock of a dense, fine-grained and interlocking crystalline structure or hard, fine-grained granites and quartzites are excellent. Where the duty imposed is not so severe, such as floors of a decorative nature, aggregates of less hardness may be selected.

Aggregates may be either gravel or crushed stone. Materials containing a large proportion of elongated or thin fragments should never be used. All aggregates should be clean, free from dust or highly weathered fragments and should consist of particles which will not alter in physical or chemical nature in the presence of moisture. New and untried aggregates should be subjected to study before they are used in finishes intended for long service under severe conditions.

Grading of Aggregates

The grading or granular composition of the aggregates is equally as important as their hardness, shape and other characteristics. The fine aggregate or sand should consist chiefly of coarser grains ranging from 1/16 to ¼ in. in size. Not more than 5 per cent of the grains should pass a 100-mesh sieve, and not more than 15 per cent should pass a 50-mesh sieve. Sand consisting chiefly of very fine particles should not be used. Stonedust, clay and silt are particularly objectionable. Gradings of fine aggregates within the limits of the following table should give good results:

	Per Cent
Passing ⅜-in. sieve	100
Passing No. 4 sieve	95 to 100
Passing No. 16 sieve	45 to 65
Passing No. 50 sieve	5 to 15
Passing No. 100 sieve	0 to 5

Coarse aggregate should be well graded pea gravel or crushed stone, the particles ranging between ⅛ and ⅜ in. in size, with all particles passing a ½-in. sieve. Gradings of coarse aggregates should be within the following limits:

	Per Cent
Passing ½-in. sieve	100
Passing ⅜-in. sieve	95 to 100
Passing No. 4 sieve	40 to 60
Passing No. 8 sieve	0 to 5

Artificial Aggregates

Artificial aggregates made by heat treatment of certain compounds in electric furnaces are sometimes used because they are hard, tough and produce non-slip surfaces. Colored ceramic aggregates are available for terrazzo. Artificial aggregates should be well graded and free from oil, grease and other harmful impurities. They should not be water-repellent. The directions of manufacturers should be followed.

Mixes for Floor Finish

The amount of mixing water should not exceed 4½ to 5 gal. per 94-lb. sack of cement. The amount of surface moisture in the aggregates should be carefully determined and this amount subtracted from that specified. The exact proportions of the aggregates will vary somewhat with their gradings and are best determined by trial.* Experience has shown that with properly graded aggregates, satisfactory results will be obtained with proportions of 1 part of portland cement, 1 part of sand and from 1½ to 2 parts of the coarse aggregate.

Workability of Concrete

Concrete should be of such proportions and have such workability that it can be compacted and each aggregate particle becomes completely surrounded by cement-water paste, leaving no honeycomb nor voids. Floor topping is laid in a relatively thin layer and is compacted by tamping, rolling, floating and troweling. Therefore a stiff mixture can be used. Stiff mixtures are advantageous, as they permit less mixing water and more aggregate with a given amount of cement and prevent segregation of the materials. Such concrete is best mixed in the open top paddle type mixer.

It is desirable to have as much as possible of the coarse aggregate near the surface of the floor to take the abrasion and wear of service. An excess of fine aggregate should therefore be avoided as it tends to work to the surface during compaction, thus defeating the purpose of the coarse material. On the other hand, the mix should not be too harsh for the methods of construction used. Harshness should be corrected by adjustment of the proportions of fine and coarse aggregate and the total amount of aggregate. The specified amount of mixing water should not be increased to produce workability.

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*The Portland Cement Association publishes the booklet *Design and Control of Concrete Mixtures* which explains proportioning by trial. This booklet may be had free of charge in the United States and Canada on request.

CONCRETE FLOORS FACILITATE HEAVY TRUCKING—At Trico Products Corporation in Buffalo, N. Y. zinc used in die casting is moved on trucks having small steel wheels. Smooth-surfaced, wear-resistant concrete was chosen as the best flooring for these conditions.

Thickness of Floor Finish

The wearing finish of concrete floors should be not less than 1 in. thick, whether it is placed at the same time as the structural slab or after the concrete in the structural slab has hardened. The thickness of structural slab will, of course, depend on design requirements.

When floors are placed over a membrane waterproofing or over insulation, a reinforced slab at least 3 in. thick should be placed over the membrane or insulation. The top 1 in. may constitute the wearing finish. These recommendations and others discussed in this booklet are summarized in the accompanying table.

RECOMMENDED THICKNESS OF CONCRETE FLOOR FINISH

Type of construction	Total thickness over structural slab, including wearing finish	Thickness of wearing finish	Reinforcement
Structural slab—bonded finish	..	1 in.	..
Structural slab—integral finish	..	1 in.	..
Terrazzo—bonded	2 in.	⅝ in.	..
Terrazzo—broken bond	3 in.	⅝ in.	..
Over membrane waterproofing	3 in.	1 in.	4x4-in. mesh #8 gage wire
Over insulation	3 in.	1 in.	4x4-in. mesh #8 gage wire
Resurfacing without removal of old finish	2 in.	1 in.	4x4-in. mesh #10 gage wire
Resurfacing after removal of old finish	1 in.	1 in.	..

Mechanical Floats and Special Methods

Mechanical floating equipment is available which will compact and float mixtures that are much stiffer and harsher than can be finished by hand methods. When these mechanical floats are used, the mixture should be so stiff that when a sample is squeezed in the hand only a slight amount of moisture is brought to the surface.

In a patented method that has given satisfaction, a plastic mixture is used, but some of the excess water used for mixing is withdrawn before the cement sets. Before the wearing course hardens, it is covered with burlap over which is spread a thin layer of carefully proportioned dry cement and sand. This absorbent mixture withdraws some of the excess mixing water from the concrete. At the proper time the burlap is removed and the wearing course is floated and finished. This process has the effect of reducing the amount of mixing water in the wearing course, with the resulting advantages previously discussed. The work is done by well trained mechanics under careful supervision.

12 YEARS OF TRUCKING HEAVY LOADS—Trucks loaded with 4 tons or more of paper have been using this floor for 12 years at Woodward and Tiernan Printing Company, St. Louis, Mo. Careful control of water content, use of tough and well-graded aggregates and adequate curing are responsible for its good performance.

Resistance of Concrete to Industrial Products

Impervious concrete is highly resistant to the action of many materials which would attack porous concrete. Lactic acid formed from milk products, weak acetic acid, brine solutions and some of the other materials used in industry will attack porous concrete, but will have little effect on dense, watertight concrete. Watertight concrete requires impervious aggregates thoroughly incorporated in a cement-water paste which is itself impervious.

Hard, dense aggregates meeting the requirements for wear resistance are impervious. Impervious paste is produced by using a low amount of mixing water, not exceeding 4½ to 5 gal. per sack of cement and keeping the concrete wet for a period. These conditions are necessary for the chemical process of hydration and are discussed under curing.

The requirement for thorough incorporation of the aggregate makes necessary the use of sufficient cement-water paste to fill the voids in the aggregates and provide a mix that will be thoroughly compacted when worked into place.

The Importance of Curing

The chemical reactions between cement and water which cause it to harden continue indefinitely if moisture is present and temperature is favorable. Through this curing process, the internal structure of the concrete is built up to provide strength, resistance to wear and watertightness. Floor finishes present such a large surface area that loss of moisture through evaporation takes place rapidly unless measures are taken to prevent such evaporation. Rapid drying not only stops the chemical reactions, but may cause dusting and also cracking of the surface due to shrinkage taking place at a time when the concrete has little strength.

To prevent drying out, water for curing should be applied to the new concrete as soon as this can be done without marring the surface. It should then be kept wet or the moisture should be sealed in by covering the floor with waterproof paper. The longer this curing period can be extended, the stronger, harder and denser will be the concrete. The curing period should be at least a week when using normal portland cement and 3 days when using high early strength portland cement. Special attention should be given to areas near warm radiators or other sources of heat, to prevent evaporation during the curing period.

Some Things to Avoid

Mortar mixes, that is, those containing sand and no coarse aggregate, should be avoided.

Overly-wet mixes and mixes containing more than 5 gal. of water per sack of cement should be avoided.

Mixes which permit water or fine material to collect on the top surface should be avoided.

Dusting on fine material to absorb excess water on the surface should be avoided for heavy-duty floors.

Excessive troweling which brings water or a large amount of fine material to the surface should be avoided.

Early drying should be avoided.

CONSTRUCTION METHODS FOR CONCRETE FLOOR FINISH

FLOOR finish may be placed after the base has hardened or while the base is plastic. The first method is preferred, as the finish is then put on after other building operations have been completed and therefore is less likely to be damaged. Better control of the water content is also obtained. Good results can be secured in either case if the base is properly prepared.

It is essential that the base be of good quality to prevent the finish from pulling away from it. Floors on the ground should have base concrete made with not more than 6 to 6½ gal. of water per sack of cement (about a 1:2½:3½ mix). The quality in floors above ground is usually governed by structural requirements.

Preparation of Hardened Base

In new construction the base course should be brought to grade not less than 1 in. below the finish grade. When it has partially hardened so that it will retain the impression of a broom, it should be brushed with a stiff-bristled broom, removing all laitance and scum. The brooming should expose some of the aggregate and score the surface to provide mechanical bond for the wearing course. The base should be wet-cured for at least 5 days unless high early strength portland cement or concrete is used which should be cured at least 2 days and it should be protected from grease, plaster, paint or other substances which would interfere with the bond.

Immediately prior to placing the finished topping, the base course should be thoroughly cleaned by scrubbing with clean water and a stiff brush. Foreign substances not removed by the scrubbing should be chipped off. If the base has been allowed to dry out, it should be thoroughly wetted. There should be no pools of water standing on the surface, however, during the next operation. Thoroughly broom into the wet surface a slush coat of cement and water mixed to the consistency of thick paint, brushing it out well to avoid too heavy a layer. The topping should then be placed immediately to avoid drying of the slush coat.

Preparation of Base for Resurfacing

On resurfacing jobs where the old floor level must be preserved, the old concrete must be cut away to a depth of 1 in. Where a new topping is to be placed directly over an old one without chipping off the old surface, the new topping should be at least 2 in. thick and reinforced with wire mesh, weighing not less than 30 lb. per 100 sq.ft. The surface of the old floor should be roughened with a pick or grinding tool. All loose particles, grease, oil, paint or other materials must be removed. Grease and oil may be removed by scrubbing with gasoline. Paint must be chipped off. Sandblasting is sometimes helpful, and scrubbing with a 10 per cent muriatic acid solution or with strong washing soda solution is helpful in removing dirt and other substances.

After the slab has been cleaned, it should be saturated overnight. A slush coat of cement and water should then be broomed into the surface just prior to placing the concrete for the topping.

Base Preparation for Integral Finish

When the finish is to be placed on the base before the latter has hardened, it is important to use a mix in the base which will not permit water to collect in puddles on the surface. If this occurs, the wearing course will absorb the excess water, greatly reducing the density, durability and strength of the finish.

The mix for the base, therefore, should be adjusted if necessary to prevent water gain on the surface. Any water that collects on the surface of the base should be removed before the wearing course is applied. The base course should have stiffened sufficiently so that footprints will not be made by the workmen when they are placing the topping.

Placing and Compacting the Topping

The exact procedure to be followed in placing and compacting the topping will depend on whether or not a mechanical float is to be used. The concrete may be spread with shovels and ordinary garden rakes to a fairly uniform level, slightly above the finished grade, and compacted with tampers or rollers or both. It should then be struck off to grade, floated with mechanical or wood floats and finally troweled to the desired finish.

ROUGHENING BASE TO INSURE BOND—Brushing the partially hardened base with a stiff wire broom cleans and scores the surface, thus assuring uniformity of bond. The surface of the hardened base must be clean, free from laitance and suitably roughened to secure good bond.

POSED PHOTOGRAPH SHOWING STEPS IN FLOOR CONSTRUCTION—Note roughness of base slab and stiffness of concrete mix being spread with shovel and rake. Concrete is then tamped and screeded, followed by floating with mechanical floats. These operations are followed by troweling and curing.

Tamping or Rolling

The concrete should be compacted throughout its depth by tamping with iron tampers or rolling with weighted rollers. This procedure gives a dense topping which is essential for a durable floor. When rollers are used, particular attention should be given the areas around columns and at walls where it is difficult to make rolling effective. Any areas that are not reached by the roller should be thoroughly tamped.

Screeding

Screeding is the operation of striking off the concrete to the proper level. When using the mechanical float some contractors place small precast concrete blocks in mortar at intervals of 8 to 10 ft. in both directions on the base. A surveyor's level or straightedge and spirit levels may be used to place these at the proper level. After the concrete has been spread and tamped or rolled, a straightedge is placed over two of the blocks and moved with a sawing motion to compact the concrete. The straightedge is not moved horizontally. Thus a line of compacted concrete the width of the straightedge (usually about 1 in.) is provided between the two blocks and this forms the screed strip. The process is repeated between the next two blocks, and so on, giving screed marks every 8 or 10 ft. in two directions. Additional screed marks are made every 4 to 5 ft. in the same way, using the screeds already placed as guides. A scraper is then used to strike off the concrete to the level of the screed strips. The scraper should be about 5 ft. long, slightly beveled on the bottom and have a strip of steel on the face. The blocks are then removed and the spaces filled with concrete.

When floating is done by hand, wood screed strips are often used. These are placed at the proper level with the aid of a surveyor's level or spirit level. The straightedge is moved across the strips in a sawing motion and at the same time is advanced horizontally to strike off the concrete. The strips are then removed and the spaces filled with concrete.

Floating

Floating is done to compact the surface, fill up the hollows and iron out the humps left after screeding and tamping or rolling. As previously stated, the power float machine will permit the use of a much stiffer, harsher mixture than can be used when floating with wood or cork floats by hand. The machine consists of a steel disk 20 to 24 in. in diameter on which a motor is mounted. By means of a handle the machine is operated over the surface of the floor. The rotating of the disk compacts the concrete and floats out the topping to a smooth surface. With the proper mixture only enough mortar will be brought to the surface for steel troweling.

Troweling

Troweling is an extremely important operation and one which requires experience and skill for the best results. It should be done at the proper time, which is after the concrete has hardened sufficiently to prevent drawing moisture and fine materials to the surface. When the mechanical float is used the first troweling may be done immediately after floating. When floating is done by hand it is necessary to use a more plastic mixture and therefore it is necessary to wait for a period after floating until the surface becomes fairly hard. Cement or mixtures of cement and sand should not be spread on the surface to absorb excess water nor should water be added to facilitate troweling. Final troweling should be done after the concrete is so hard that no mortar accumulates on the trowel and a ringing sound is produced as the trowel is drawn over the surface. This will polish the surface to a smooth finish.

Curing

Proper treatment of the floor after it has been troweled is too often neglected. As stated previously, the concrete must be kept moist so that the cement will continue to combine chemically with the water. This curing process should be started as soon as possible. If it is delayed so that rapid evaporation takes place in the early stages, the surface may crack, craze or dust. The longer the concrete can be kept wet, the stronger, denser and more wear-resistant it will be.

There are several methods of curing concrete floors. The ponding method is sometimes used, in which the floor slab is surrounded by small dikes of sand and the enclosure kept filled with water to a depth of an inch or so. Frequent sprinkling of the surface and covering the exposed surface with wet sand or wet burlap are other ways of providing curing. Such coverings should be placed as soon as this can be done without marring the surface and then should be kept continuously wet.

Heavy paper impregnated with asphalt to make it waterproof is also used for curing. This is placed as soon as it can be done without marring the surface and will protect the floor from dirt and debris resulting from other building operations. All seams should be lapped and sealed with glued tape to provide a continuous waterproof covering.

In cold weather construction when artificial heating devices are used, special precautions are required. The high temperatures near the heating devices cause rapid drying unless the concrete is well protected. Heaters should be raised and the floor underneath for a distance of several feet on all sides of the heater should be covered with 3 or 4 in. of sand. The sand should be kept saturated with water through the curing period.

Cold Weather Precautions

Concrete hardens very slowly at temperatures below 50 deg. F. and the hardening practically ceases at freezing temperature. Special precautions are required for all concrete work in cold weather, but because of the relatively thin layer of concrete and large area of exposure in floor finish, such precautions are particularly important. All concrete should be protected from freezing until it has gained sufficient strength so that it will not be damaged. When necessary, heat should be furnished to provide the necessary temperatures.

On leaving the mixer, the fresh concrete should be free from ice or frozen lumps and should have a temperature of not less than 70 nor more than 80 deg. F. Heating only the mixing water is often sufficient; in other cases it may be necessary to heat both mixing water and aggregate to meet these requirements. The concrete temperature should then be maintained above 70 deg. F. for at least 3 days, or above 50 deg. F. for at least 5 days when using normal portland cement and above 70 deg. F. for at least 2 days or above 50 deg. F. for at least 3 days when using high early strength portland cement. The floor should be kept wet during this period.

Grinding

Some concrete floors are finished by grinding. Mechanical grinders remove the thin film of cement paste that covers the surface after troweling, thereby exposing the aggregates. Floor finish to be ground need have only one troweling.

Grinding should not be started until the concrete has cured and hardened sufficiently so that aggregate particles will be cut and not torn from the surface. Large double-disk electrically operated grinding machines, such as those used for finishing terrazzo floors, have been found economical. The floor is generally kept saturated during the grinding process. When necessary, air holes and pits may be filled with a cement grout of creamy consistency.

Cleaning the Finish

The new floor finish should be protected from accumulations of building debris until the completion of the structure. To remove accumulated dirt, the surface should be well swept with a stiff broom and thoroughly scrubbed with white soapsuds. A scrubbing machine fitted with wire brushes or pads of fine steel wool is very effective. The suds and dirt should be mopped up and the surface flushed with clean warm water and again mopped.

SCREEDING CONCRETE TO PROPER LEVEL—After tamping the concrete, screed strips are made at about 10-ft. intervals. The excess concrete is then scraped off to the level of the screed strips, using a short screed fitted with a steel edge.

MECHANICAL FLOATING CONCRETE FLOOR FINISH—The rotating steel disc of the mechanical float compacts the concrete, smooths out the hollows and high spots and brings just enough mortar to the surface for troweling.

PRODUCING AN EVEN CONCRETE FLOOR FINISH—A long float will remove the inequalities left by the short float and produce an even, plane finish. Notice the absence of water at the surface.

HAND FLOATING AND TROWELING CONCRETE FLOOR FINISH—Finishing operations play an important part in determining the utility, appearance and durability of the wearing course. Proper floating fills up the hollows and compacts the concrete. It may be done by hand, as shown, or by mechanical floats. Troweling further compacts the wearing course and produces a smooth surface so necessary for efficient trucking.

SPECIFICATIONS FOR HEAVY-DUTY CONCRETE FLOOR FINISH

1. Base Slab

The surface of the structural base slab shall be finished reasonably true and struck off at a level not less than 1 in. below the required finish grade.

As soon as the condition of the concrete base permits and before it has fully hardened, all dirt, laitance and loose aggregate shall be removed from the surface by means of a wire broom, which shall leave the coarse aggregate slightly exposed, or the surface otherwise roughened to improve bond with the topping.

When it is impossible to remove laitance and roughen the slab by brooming, the surface shall be cleaned and prepared for bond by chipping after the base has hardened.

Just prior to placing the finish, the base slab shall be thoroughly cleaned by scrubbing, to the satisfaction of the engineer.

Note: When the wearing course is to be placed on same day as the base slab, only the first paragraph of this section should be used.

2. Portland Cement

Portland cement shall be of American manufacture conforming to the "Standard Specifications for Portland Cement" (Serial Designation: C9-38) or the "Standard Specifications for High Early Strength Portland Cement" (Serial Designation: C74-39) of the American Society for Testing Materials, and subsequent revisions thereof.

3. Aggregates

Fine aggregate shall consist of clean, hard sand or crushed stone screenings free from dust, clay, loam or vegetable matter and shall be graded from coarse to fine to meet the following requirements:

	Per Cent
Passing ⅜-in. sieve	100
Passing No. 4 sieve	95 to 100
Passing No. 16 sieve	45 to 65
Passing No. 50 sieve	5 to 15
Passing No. 100 sieve	0 to 5

Coarse aggregate shall consist of clean, hard gravel or crushed stone free from dust, clay, loam or vegetable matter, and from coatings which will tend to weaken the bond. It shall contain no soft, flat or elongated fragments and shall be graded to meet the following requirements:

	Per Cent
Passing ½-in. sieve	100
Passing ⅜-in. sieve	95 to 100
Passing No. 4 sieve	40 to 60
Passing No. 8 sieve	0 to 5

All aggregates shall be selected with care and shall be of an approved character. Samples of proposed material shall be submitted to the engineer for approval prior to use.

4. Mixture

The nominal mixture shall be 1 part of portland cement, 1 part of fine aggregate and 2 parts of coarse aggregate by volume. This nominal mix may be slightly varied, depending upon the local conditions, and as the engineer may direct. If the aggregate is very coarse, the gravel or stone may be reduced, but in no case shall the volume of the coarse material be less than 1½ times the volume of the fine.

The mixture shall be determined by the engineer and once established shall not be changed except upon his written order.

Not more than 5 gal. of mixing water, including the moisture in the aggregates, shall be used for each sack of portland cement in the mixture.

The mixing of the concrete shall continue for at least 1½ minutes after all ingredients are in the mixer.

5. Consistency

The concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board, or straightedge. Changes in consistency shall be obtained by adjusting the proportions of fine and coarse aggregate within the limits specified. In no case shall the specified amount of mixing water be exceeded.

6. Placing and Compacting

The base slab shall be thoroughly wetted just prior to the placing of the finish, but there shall be no pools of water left standing on the wetted surface. A thin coat of neat cement grout shall be broomed into the surface of the slab for a short distance ahead of the topping. The wearing course shall be applied before the grout has hardened, and brought to the established grade with a straightedge. After striking off the wearing course to the established grade, it shall be compacted by rolling or tamping, and then floated with a wood float or power floating machine. The surface shall be tested with a straightedge to detect high and low spots, which shall be eliminated.

Note: When the wearing course is to be placed on same day as the base slab, the following should be substituted for the first three sentences of this section:

Water and laitance which rise to the surface of the base slab shall be removed before applying the wearing course. After concrete in the base slab has settled sufficiently so that water does not rise to the surface but within 1 hour after placing the base slab, the wearing course shall be applied and brought to the established grade with a straightedge.

7. Finishing by Troweling

Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. No dry cement nor mixture of dry cement and sand shall be sprinkled directly on the surface of the wearing course to absorb moisture or to stiffen the mix. After the concrete has further hardened, additional troweling may be required. This shall be done as may be directed by the engineer.

Note: Surfaces to be ground shall be swept with soft brooms after rolling to remove any water and surplus cement paste that may be brought to the surface. The wearing course shall then be floated and once lightly troweled, but no attempt shall be made to remove all trowel marks.

8. Curing and Protection

All freshly placed concrete shall be protected from the elements and from all defacement due to building operations. The contractor shall provide and use tarpaulins when necessary to cover completely or enclose all freshly finished concrete.

If at any time during the progress of work the temperature is, or in the opinion of the engineer will, within 24 hours, drop to 40 deg. F., the water and aggregate shall be heated and precautions taken to maintain the temperature of the concrete above 70 deg. F. for at least 3 days or above 50 deg. F. for at least 5 days when using normal portland cement, and above 70 deg. F. for at least 2 days or above 50 deg. F. for at least 3 days when using high early strength portland cement.

As soon as the concrete has hardened sufficiently to prevent damage thereby, it shall be covered with at least 1 in. of wet sand or other covering satisfactory to the engineer, and shall be kept continually wet by sprinkling with water for at least 7 days when using normal portland cement or for at least 3 days when using high early strength portland cement. In lieu of other curing methods, the concrete may be covered with asphalt-impregnated, waterproofed paper. All seams of such paper shall be overlapped and sealed with tape.

9. Finishing by Grinding

After the wearing course has hardened sufficiently to prevent dislodgment of aggregate particles, it shall be ground down with an approved type of grinding machine shod with rapid-cutting abrasive stones to expose the coarse aggregate. The floor shall be kept wet during the grinding process. All material ground off shall be removed by squeegeeing and flushing with water.

Air holes, pits and other blemishes shall then be filled with a cement grout of creamy consistency. This grout shall be spread over the surface and worked into the pits with a steel straightedge, after which the grout shall be rubbed into the floor surface with the grinding machine. The floor shall be kept moist for an additional 3 days.

The surface shall then receive a second or final grinding to remove the film and to give the finish a polish. It shall then be thoroughly washed and all surplus material removed.

SPECIFICATIONS FOR RESURFACING

Many old floors have been subjected to service that was too severe for the quality of the surface. Such floors may be resurfaced to provide a topping which will withstand heavy duty indefinitely. The specifications for heavy-duty floors may be used by changing designated paragraphs as follows:

Where old floor level must be preserved and where it is otherwise practicable to chip off the old floor topping, substitute the following for Section 1:

1. Base

The top of the old floor shall be removed to a depth of at least 1 in. The base shall be thoroughly cleaned of all loose material and dust to the satisfaction of the engineer.

Where it is not practicable to chip off the old topping and the floor level may be raised, the following provisions may be substituted for Sections 1 and 6:

1. Base

The top of the old floor shall be thoroughly cleaned of all loose material, dust, paint, grease, oil or other material to the satisfaction of the engineer. Areas having the original troweled finish shall be roughened.

6. Placing and Compacting

The base slab shall be thoroughly wetted prior to placing the finish, but there shall be no pools of water remaining when the wearing course is to be placed. A thin coat of neat cement grout shall be broomed into the surface of the slab for a short distance ahead of the topping. Before the grout hardens, the wearing course shall be applied to a thickness of about 1 in. Wire mesh weighing not less than 30 lb. per 100 sq.ft. shall be laid and placing of the wearing course resumed to a total thickness of not less than 2 in. After striking off the wearing course, it shall be compacted by rolling or tamping and then floated with a wood float or power floating machine. The surface shall be tested with a straightedge to detect high and low spots, which shall be eliminated.

ROTUNDA OF THE CINCINNATI UNION TERMINAL—Color and bold pattern in this beautiful terrazzo floor complement the mural paintings on the walls and the colorful dome to produce a harmonious and magnificent interior.

DECORATIVE CONCRETE FLOOR FINISHES

Terrazzo

TERRAZZO floor finishes offer unlimited possibilities for decorative effects in concrete, thus combining beauty and durability. In large areas of plain color or in patterns of many colors, terrazzo floors are widely used in banks, office and hotel buildings, churches and other public or social buildings, display and sales rooms, vestibules, lobbies and corridors, and are finding popular acceptance in the home.

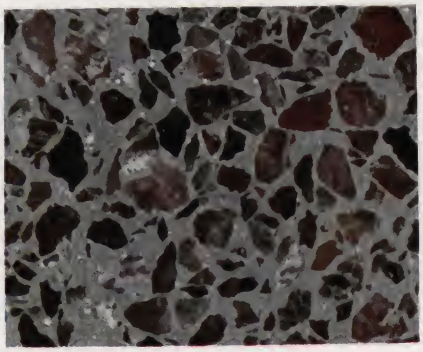
Plain terrazzo provides attractive, long-wearing floors at low cost. More decorative effects are produced by introduction of pattern and by increasing the number of colors. The original beauty of terrazzo is retained with a minimum of upkeep and terrazzo surfaces are easily kept clean and sanitary. Stairs, ramps, coves, bases and wainscots are also made in terrazzo to match or contrast with the floors.

Terrazzo is produced by laying mixtures of concrete containing marble chips or other aggregates of the desired colors. Additional aggregate is rolled into the fresh concrete when necessary so that 70 to 85 per cent of the finished floor area will consist of aggregate. Coloring pig-

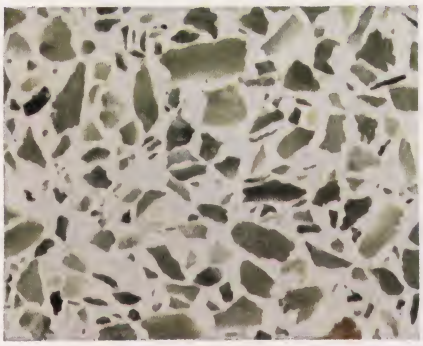
A FEW OF THE COLOR COMBINATIONS USED IN FINE TERRAZZO

Belgian Black marble.

Domestic White marble.

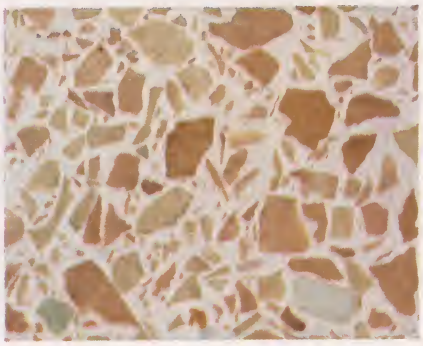


Red Levanto marble and green and black pigments.



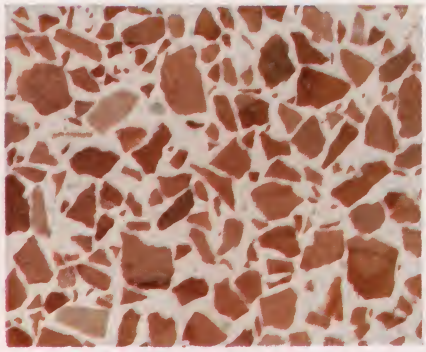
Royal Green marble.

Coral Pink marble.

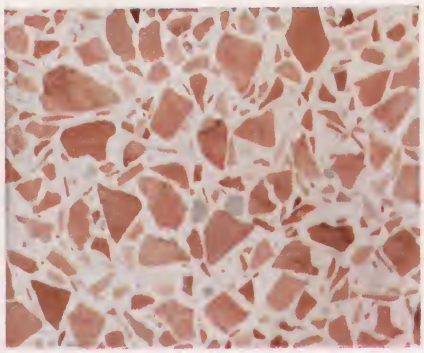


Yellow Verona marble.

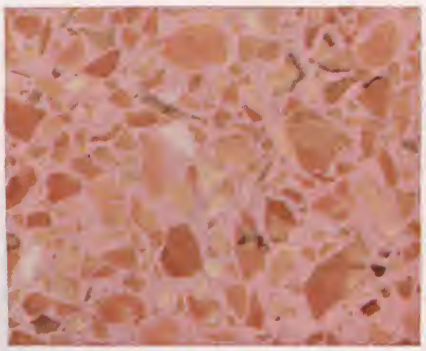
Yellow Verona marble and yellow pigment.



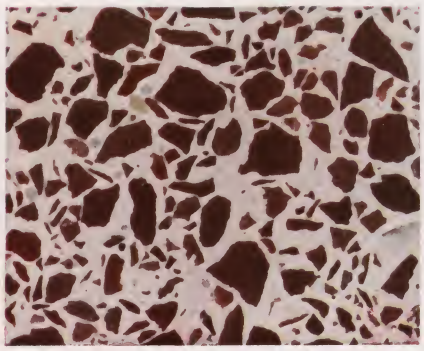
Red Verona marble.



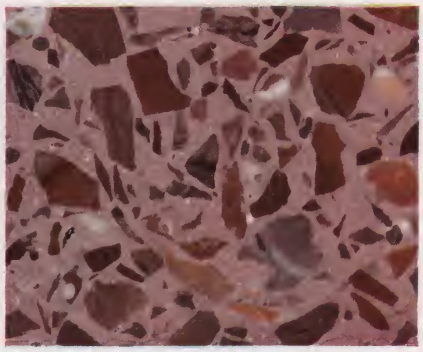
Red Rosa marble.



Red Rosa marble and red pigment.



Turkish Red marble.



Red Champlain marble and red and black pigments.

ments may be added to produce a matrix of almost any shade and color desired. White portland cement should be used where clarity of color is important. After the concrete mixtures have hardened for several days, the surface is ground and highly polished.

Brass strips or dividing strips of other suitable material are used to separate the colors for the desired pattern. They also prevent shrinkage cracks which are particularly objectionable in decorative floors. The terrazzo course may be bonded to the structural base slab or may be separated by means of a sand cushion ¼ in. thick and a layer of tarpaper. Structural cracks which occur in the base slab will not be transmitted to the terrazzo top course if this is separated from the base.

An underbed of 1:4 mortar, about 1½ in. thick, is placed and the dividing strips are inserted in the mortar in the desired pattern. When this has hardened sufficiently, the terrazzo mixtures consisting of 1 part of portland cement and 2 parts of aggregate are applied. The floor is then rolled until thoroughly compacted and after hardening sufficiently it is ground and polished.

Skilled labor working under adequate supervision is necessary for a good terrazzo job. The work should be entrusted to floor specialists whose experience has shown them capable of rendering the class of workmanship desired. Specifications for terrazzo floor finishes follow.

SPECIFICATIONS FOR TERRAZZO WORK

1. Base Slab

The surface of the structural base slab shall be struck off reasonably true at a level not less than — in. below the required finish grade.

Note: Insert 1¾ in. for Method A or 2½ in. for Method B.

2. Samples

Samples of the aggregates shall be submitted for approval by the architect. Samples of the terrazzo shall be made in duplicate for approval by the architect.

3. Aggregates

The aggregates shall be (insert the kind and color desired) and graded in sizes No. 1, 2 and 3.

4. Color Pigments

Pigments shall be commercially pure natural or synthetic mineral oxides or other coloring materials manufactured for use in portland cement mixtures and proved satisfactory. Pigments shall be in the manufacturer's original container.

5. Mixtures

The base for terrazzo finish shall be mixed in the proportions of 1 part of portland cement to 4 parts of clean, coarse sand.

The terrazzo mixture shall be in the proportions of 200 lb. of aggregate to 1 sack of portland cement (where clear colors are important, use white portland cement) with not more than 4 gal. of water and the proper amount of pigment to produce the approved color. The cement and pigment shall be mixed dry to a uniform color before adding the other materials. The terrazzo mixture shall be of the driest consistency possible to work into place with a sawing motion of the strike-off board or straightedge. Changes in consistency shall be obtained by changes in the proportions of aggregate and cement. In no case shall the specified amount of mixing water be exceeded.

6. Placing

Method A—Bonded Finish—The surface of the structural base slab shall be cleaned of all plaster and other materials that would interfere with the bond and shall be thoroughly wetted. It shall be slushed with a neat cement grout thoroughly broomed into the surface. The underbed shall then be spread uniformly and brought to a level not less than ½ in. nor more than ¾ in. below the finished floor.

Method B—Broken Bond Finish—The surface of the structural base slab shall be covered with a uniform layer of fine sand ¼ in. thick, and covered with an approved tarpaper overlapping at least 2 in. at all edges. The underbed shall then be spread uniformly and brought to a level not less than ½ in. nor more than ¾ in. below the finished floor.

While the underbed is in a semi-plastic state, the dividing strips shall be installed to conform to the designs shown on the drawings. The top of the strips shall be at least ½ in. above the finished level of the floor.

The terrazzo mix shall then be placed in the spaces formed by the dividing strips and rolled into a compact mass by means of heavy rollers, adding aggregate if necessary so that the finished surface shall show a minimum of 70 per cent aggregate. Immediately after rolling, the surface shall be floated and troweled to an even surface disclosing the lines of the strips on a level with the terrazzo filling.

7. Curing and Protection

All freshly placed concrete shall be protected from the elements and from all defacements due to building operations. As soon as the concrete has hardened sufficiently to prevent damage thereby, it shall be covered with at least 1 in. of wet sand or other covering satisfactory to the architect, and shall be kept continually wet by sprinkling with water for at least 7 days when using normal portland cement and for at least 3 days when using high early strength portland cement. The temperature of the concrete at time of placing shall be above 70 deg. F. and it shall be maintained above 70 deg. F. for at least 3 days or above 50 deg. F. for at least 5 days when using normal portland cement and above 70 deg. F. for at least 2 days or above 50 deg. F. for at least 3 days when using high early strength portland cement.

8. Surfacing

When the terrazzo concrete has hardened enough to prevent dislodgment of aggregate particles, it shall be machine rubbed, using No. 24 grit abrasive stones for the initial rubbing and No. 80 grit abrasive stones for the second rubbing. The floor shall be kept wet during the rubbing process. All material ground off shall be removed by squeegeeing and flushing with water.

A grout of portland cement, pigment and water of the same kind and color as the matrix shall be applied to the surface, filling all voids.

In not less than 72 hours after grouting, the grouting coat shall be removed and the surface polished to a satisfactory finish by machines using stones not coarser than No. 80 grit.

9. Cleaning

After removing all loose material, the finish shall be scrubbed with warm water and soft soap and then mopped dry.

10. Non-Slip Terrazzo

Where specified, the terrazzo shall be made non-slip by the addition of abrasive aggregate meeting the approval of the architect. The abrasive shall be mixed with the terrazzo mixture or sprinkled on the surface only as indicated. Where it is to be mixed with the terrazzo mixture, the aggregate shall consist of 40 per cent abrasive aggregate and 60 per cent of other aggregate as specified. Where it is to be sprinkled on the surface only, the finished surface shall show uniform distribution of 1 part of abrasive aggregate to 4 parts of other aggregate as specified.

Note: It is suggested that for heavy-duty floors the abrasive be incorporated in the terrazzo mixture. For light-duty floors it may be sprinkled on the surface.

Concrete Tile and Art Marble

Beautifully colored, long-wearing floors of precast concrete tile are used in residences, office buildings, hotels, churches and similar structures. When made of marble chips and ground and polished, the tile are often referred to as art marble. The tile may be secured in many colors, shapes and patterns, and special designs may be made to order. They should be secured from reliable manufacturers.

When tile are to be installed, the concrete base course is brought to within 2 or 2¼ in. of the finished grade, left with a rough surface and allowed to harden. Mortar of 1:3 mix is placed on the dampened base and the tile are laid in the desired pattern. Before the tile are laid, they should be soaked in water for 10 or 20 minutes, and then allowed to dry for about the same length of time, the object being to have them uniformly damp, but not saturated with water. Tile should be laid by experienced mechanics.

Color with Pigments

A wide range of color is obtainable with the use of mineral coloring pigments mixed with the concrete finish. A single uniform color such as red, green or brown is most widely used in floors of this type, although a border of one color and field of another as well as simple patterns involving two or more colors have been used to some extent.

Only pigments resistant to alkali should be used. Mortar colors containing a large percentage of filler are not suitable. Pure mineral pigments and factory-prepared mixtures of cement and mineral pigment are available for the purpose. Manufacturer's directions should be carefully followed. Where mixing is to be done on the job, it should be very thorough to secure uniform dispersion and full color value of the pigment.

Various methods of mixing are used. The pigment may be added to the other dry ingredients and mixed thoroughly before the water is added. A color mixer or small ball mill may be used to mix the cement and pigment to a uniform color before these are added to the aggregate and water. Another method of mixing the pigment and cement is to pass them through a ⅛-in. or finer sieve until the mixture is uniform. After all the ingredients are in the mixer, the batch should be mixed for at least 2 or 3 minutes and until it is uniform.

The color values of pigments vary with their fineness and purity. In comparing them, one should be guided by the amounts required to produce the desired color and shade. This can best be done by making test samples, allowing them to dry. The accompanying table may be used as a guide to the approximate quantities of high-grade pigments required for the colors and shades indicated.

PIGMENTS FOR COLORED CONCRETE FLOOR FINISH

Color desired	Commercial names of colors for use with cement	Approximate quantities required—lb. per bag of cement	
		Light shade	Medium shade
Greys, blue-black and black	Germantown lampblack*	½	1
	or carbon black*	½	1
	or black oxide of manganese*	1	2
	or mineral black	1	2
Blue	Ultramarine blue	5	9
Brownish red to dull brick red	Red oxide of iron	5	9
Bright red to vermilion	Mineral turkey red	5	9
Red sandstone to purplish red	Indian red	5	9
Brown to reddish-brown	Metallic brown (oxide)	5	9
Buff, colonial tint and yellow	Yellow ochre or	5	9
	yellow oxide	2	4
Green	Chromium oxide or greenish blue ultramarine	5	9
		6	

*Only first-quality lampblack should be used. Carbon black is light in weight and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 lb. of oxide for each bag of cement.

Dusted-on Color

For some floors subject only to light foot traffic, a dusted-on color mixture has been used. A 1-in. wearing course as recommended for heavy-duty floors is placed, and after screeding to the proper level a dusted-on mixture is applied immediately. This mixture is made in the proportions of about 1 part of cement, 1 to 1½ parts of sand and the required amount of pigment. The sand should be well graded with at least 80 per cent passing a No. 8 sieve and not more than 3 per cent passing a No. 30 sieve. The mixture should be applied uniformly at the rate of not less than 125 lb. per 100 sq.ft. of floor area.

After spreading the dry material it should be floated and worked into the slab. The first floating should be discontinued as soon as the surface becomes wet. Floating should be resumed when surface moisture has disappeared. After testing with a straightedge and high and low spots are eliminated, the finish should be troweled to a smooth surface free from defects or blemishes. The concrete should then be cured as recommended for other floor finishes.

Stained Floor Finish

Attractively colored floors are secured with the use of certain inorganic chemicals. These are applied to the hardened floor and react with the cement to form new

METAL DIVIDING STRIPS IN PLAIN CONCRETE FLOOR—Metal dividing strips like those used in terrazzo are often used in plain or colored concrete floor finish. This floor is in locker room of gymnasium at Amherst College, Amherst, Mass.

compounds in the concrete to produce the color. Several applications are often necessary before the desired effects are attained. A mottled or multi-tone effect is generally produced, depending somewhat on the amount of troweling done in finishing. A number of manufacturers can supply the materials used.

Painted Finish

Concrete floor finish may be painted to attain any color effect. Oil paints, rubber-base paints and synthetic resin paints are available for this purpose. It should be realized that any traffic causes a certain amount of wear and in aisles and other places where foot traffic is heavy, touching up at intervals may be necessary and an occasional complete repainting required to keep a good appearance. Painting is not advisable where there is heavy truck traffic or dragging of boxes or other objects over the floor.

Concrete should be clean and thoroughly dry when it is to be painted. The painting should not be done for several months after construction to give ample time for curing and drying. The surface should be neutralized by mopping it with a solution containing 4 lb. of zinc sulphate per gallon of water. After allowing 48 hours for this solution to react with the concrete and dry, the surface should be cleaned with water to remove all crystals. It should then be allowed to dry thoroughly before applying the paint.

Three coats of paint are recommended. The first coat should be very thin—about equal parts of thinner and paint give about the proper consistency. Some thinner may be used for the second coat and the third coat may be applied as it comes from the can.

Scoring and Division Strips

Concrete floors may be marked off into conventional patterns by the use of an ordinary grooving tool on the fresh concrete or with a power-driven carborundum disk cutting appliance on the hardened concrete. An objection to grooves is the difficulty of keeping them clean. When the floor is mopped the dirt is deposited in the grooves.

Another method of marking off the floor surface is with metal strips like those used for terrazzo. These have the advantage of eliminating open scoring joints. Shrinkage of the surface tends to localize along the strips, thus preventing surface cracking. The strips are available in brass, nickel silver and zinc in 12 to 18 gage and from 1 to 1⅜ in. wide. For joints more than ⅛ in. wide, strips of the "heavy top" type are used.

Division strips are used both in single color floors and in floors having two or more colors. In general, they should be placed not more than 4 ft. apart to be effective. In floors to be finished by troweling and not to be ground, care must be exercised to set the strips at the exact finished level.

Dance Floors

Smooth concrete floors make excellent surfaces for dancing. Terrazzo and trowel finished colored floors are widely used for interior dance floors. Concrete is also ideal for out-of-doors dance floors as it resists weathering, is quickly put into service after rain and requires a minimum of maintenance. Many hotels, summer gardens, country clubs and similar organizations have built such outdoor floors.

Outdoor floors should be designed and constructed to withstand the wide range of temperature variations and conditions of weathering. When placed directly on the ground, drainage away from the floor should be provided. A well drained cinder, gravel or crushed stone fill at least 6 in. thick should be provided. A base slab at least 4 in. thick of 1:2:3 concrete should be placed on the fill. While still plastic, temperature reinforcement should be placed on this concrete, followed immediately by the finish course. The finish should be constructed as recommended for heavy-duty floors.

Temperature reinforcement should consist of at least ¼-in. bars, spaced at 6-in. centers in both directions, or an equivalent area of steel in wire fabric or expanded metal. In unstable earth, structural reinforcement may be needed in the lower part of the slab. A competent engineer should be consulted for such cases as well as for floors of exceptional area and irregular shapes.

Dance floors must be smooth and preferably waxed. When such floors are given a trowel finish, a very hard, smooth surface is secured by troweling after the concrete is hard enough to produce a ring as the trowel passes over it. Terrazzo floors are polished by mechanical equipment and are very smooth.

Various treatments are used for preparing concrete floors for dancing. In most cases a satisfactory polish is secured with ordinary floor wax. Paste wax should be used for the first two or three applications; after that either paste or liquid wax may be used. Powdered wax, powdered boric acid and powdered soap also are suitable. Some floors have been treated with paraffin wax dissolved in turpentine, followed by a coating of powdered wax.

Scrubbing the floor with strong soap solution before waxing and an occasional scrubbing and rewaxing are desirable to keep the floor in good condition.

FLOORS SUBJECT TO SPECIAL CONDITIONS

Creameries, pickling and packing plants, food products plants, breweries—Floors exposed to impact, rapid changes in temperature, strong acids or corrosive materials

SOME materials used in industry will attack concrete of inferior quality but will have little if any effect on dense, hard concrete floor finish. Lactic acid as found in some milk products and vinegar or other organic acids resulting from fermentation of food products, fruit juices and many other materials are in this class. The smoothness of properly constructed concrete floors, their low absorption and their freedom from joints and crevices prevent the accumulation of these materials and make it relatively easy to keep them clean.

Other materials such as salt or sugar solutions will be absorbed by porous floors. Due to crystallization of the absorbed solution, sufficient stress is created to cause gradual disintegration. Concrete floors of good quality will not absorb the solution and hence will withstand the action of these materials indefinitely.

For all these exposures, then, concrete floor finish constructed as recommended for heavy-duty floors should be provided. As further protection against the possibility of absorbing any of these materials, a surface treatment may be used to fill the surface pores. The treatment is given after the concrete has cured and dried.

A simple treatment is the application of warm linseed oil, Chinawood oil or soybean oil. To assist penetration, the oil should be thin. For the first coat, equal parts of the oil and turpentine or other suitable thinner may be used. A second application with a somewhat thicker solution may be given if the first one is well absorbed. The oil may be applied with mops or brushes and the excess removed with a squeegee before the oil gets tacky. An occasional application of the oil after the floor is in service will be helpful. This should be done only after the floor has been thoroughly cleaned.

Another treatment is the application of paraffin. The paraffin should have a melting point of 150 deg. F. It is made into a paste by melting 4 parts by weight with 1 part of turpentine and 16 parts of toluol. Toluol is a solvent obtained from coal tar and is generally available from chemical supply houses. The mixture is spread on the floor and allowed to penetrate for 24 hours. The floor should be as warm as possible. At the end of this time the residual layer should be driven into the concrete by heat. A free flame should not be used due to fire hazard; hot irons will be found safe and effective in forcing the paraffin into the pores of the finish.

After either of these treatments, the floor may be waxed for further protection. As the wax film is worn away, it should be replaced. A floor-polishing machine may be used. Waxing is of considerable assistance in keeping the floor clean.

Rapid Temperature Changes

In many creameries and other plants, large vats of boiling water are dumped onto the floor to flow into drains, subjecting the concrete to rather rapid changes in temperatures. Light wire mesh may be placed in the finish course to reinforce the concrete and prevent cracks due to this type of service. The mesh should be 4x4-in. No. 10 gage wire weighing 31 lb. per 100 sq.ft., and should be placed near the middle of the wearing course.

Armored Floors

Concrete floor finish in receiving rooms, unloading platforms and in other locations where they will be subject to impact from falling objects may be reinforced with a special metal grid or armor grating placed in the surface. Armoring is also used in floors to be subjected to heavily loaded steel-tired trucks or to sliding loads. Armor of several varieties is available consisting of grey iron castings, strips of steel assembled by bolts, welding, rivets or wires, and cold-drawn carbon steel open-work sections

The armor should be installed in accordance with the manufacturer's recommendations with the top surface at the exact level of the finished floor. Care should be taken to fill all openings in the grille. The concrete should be made, placed, finished and cured as recommended for heavy-duty floors.

Acid-Proof Floors

Floors in chemical laboratories, acid plants, dye houses, storage battery buildings and similar structures in which strong acid solutions or other strong corrosive materials are manufactured or handled may require the protection of an acid-proof covering. Asphalt mastics, asphalt blocks or acid-proof brick or tile laid in acid-proof mortar may be used for this purpose.

The base slab is placed and finished some distance below the grade of the finished floor surface, depending on the thickness of the finish. The surface may be screeded to proper elevation, pitching it to the drainage fixtures which also should be of acid-proof material. Where asphalt block are to be used, the surface should be troweled smooth. The base should be kept moist and allowed to harden before the top course is laid.

Asphalt block may be placed directly on the base, setting them as close together as possible. The surface is then pointed with hot asphalt and a layer of clean fine sand is dusted on. The block weld to a continuous surface under traffic. Mixtures of asphalt and aggregate may be installed also as a continuous sheet from 1 to 1½ in. thick. Asphalts should not be exposed to hot water or other hot materials, fats, greases or oils.

When brick or tile are used, these may be set in an underbed of cement mortar, leaving the joints open. The joints may then be filled with acid-proof material.

For certain corrosive conditions, notably dilute solutions of sulphuric acid and sulphates, a concrete floor topping using a calcium aluminate cement with acid resistant aggregates has proven satisfactory. Calcium aluminate cement differs from portland cement in its composition. It is used in much the same manner, but requires all of its curing within 24 hours after mixing because of its rapid hardening.

Non-Slip Floors

In certain locations, more non-slip quality than usual is desired in floor finish. This may be accomplished by roughening the surface immediately after final troweling or by incorporation of non-slip aggregates. Roughening may be done with a fine hair brush but this finish is seldom used for interior floors because of the difficulty in keeping the floor clean.

A METHOD OF PRODUCING A COARSE-GRAINED FINISH—After the surface has been troweled, the surface is lightly brushed in one direction with a hair broom to produce small grooves. For areas subject to heavy duty, coarse-grained finish is obtained better by the use of non-slip aggregates embedded in the surface.

Non-slip aggregates may be mixed with the concrete or sprinkled on the surface of the wearing course just prior to finishing. More of the aggregate is required when it is mixed with the concrete but the distribution is more uniform. Approximately ¾ to 1 lb. of non-slip aggregate is required per square foot of floor.

When applied only to the surface, from ¼ to ½ lb. of abrasive is used per square foot. The aggregate should be scattered uniformly over the unhardened concrete just prior to compacting and worked into the surface during finishing. After the floor has hardened, the surface may be ground or scrubbed with floor-scrubbing machines using pads of steel wool. This removes the film of cement on the surface and exposes the non-slip aggregate.

COVERED FLOORS

WHERE concrete floors are to be covered with linoleum, composition tile, prefinished wood tile or planking, carpeting or similar materials, it is not necessary to provide a heavy-duty wearing surface on the concrete. The dust coat method of finishing may then be used.

The structural slab is struck off reasonably true at the required floor level and excess water or laitance removed. A mixture of dry materials consisting of 1 part of portland cement and 2 parts of coarse, clean sand is dusted on the unhardened concrete in a uniform layer not over ⅛ in. thick. When the dry materials have absorbed moisture from the slab and the concrete has hardened enough to allow finishing, it is floated and troweled to unite the dust coat with the base and give an even surface free from air holes, depressions and other blemishes. The floor should be protected and cured as recommended for other types. This dust coat method of finishing should not be used for uncovered floors where the finish would be directly subjected to traffic.

Wood, Linoleum, Rubber and Cork Tile

When wood, linoleum, rubber or cork tile is to be used, the concrete must be thoroughly dry before cementing the surfacing material into place. Moisture, even in very small quantities, will eventually lead to the decomposition of the adhesive. A simple test to determine whether or not the concrete is dry may be made by laying pieces of linoleum at several places on the floor, weighting them down so they will have uniform contact with the surface. If after 24 hours moisture appears on the underside of the linoleum, it will be necessary to let the concrete dry further before cementing the covering to it. The directions of the manufacturer of the materials being used should be followed.

Carpet

Floors to be covered with carpet require wood nailing strips, usually around the border of the area. These should be well seasoned lumber, dressed to 1x2 in. and embedded in the unhardened concrete. Special snap inserts are sometimes embedded in the concrete instead of nailing strips. In this case fastening devices are attached to the underside of the carpet.

The surface of the concrete floor should be screeded and troweled flush with the tops of the wood strips and should present a smooth, even surface. It should be cured and allowed to dry before placing the carpet. Pads or cushions under the carpet prolong the life of the carpet and assist in producing soundproofness.

REPAIRS, MAINTENANCE AND TREATMENT

FLOORS are sometimes so poorly built as to be wholly inadequate for the service intended. In such cases it is advisable to remove the defective top surface and replace it with a new one in accordance with the suggestions given previously. Failure to observe some fundamental requirement in construction may result in certain defects which often can be corrected by proper treatment or repairs.

Dusting

Floor finishes that dust under service may usually be improved by one of the hardener treatments discussed on page 23. Whether the hardener treatment will entirely stop dusting will depend on the construction methods used and the resulting condition of the surface.

Where there is a thin layer of soft, chalky material at the surface, this may often be removed with pads of steel wool attached to a scrubbing machine. After removal of this material, the surface should be thoroughly cleaned, then allowed to dry and one of the hardener treatments applied. In other cases, it is necessary to grind the surface before treatment.

Cracking

Cracks in concrete floors may be classified as (1) structural cracks originating in the base and extending through the finish, and (2) cracks confined to the wearing course. The latter may extend through the wearing course, or may be of a superficial nature, ordinarily called hair cracks or crazing.

Structural cracks may be caused by shrinkage, temperature changes or settlement. If there is recurrent movement, there is little that can be done other than to keep them filled with a mastic material. Crazing cracks may be removed by grinding if they are not too deep. The only other method of removing them is to remove the affected area and replace it with new material.

In many cases cracks may be filled with varnish or resin. Although they will remain visible, accumulations of dirt and leakage will be prevented. Artificial resins such as Cumar (available through paint and varnish manufacturers) may be used. This should be powdered and dissolved in a suitable solvent such as xylol, in the approximate proportions of 6 lb. of resin per gallon of solvent. A varnish-like material is produced which can

be run into the cracks. Cement may be added to make a thicker solution for wider cracks.

In patching concrete floors, the old wearing surface should be chipped off to a depth of at least 1 in., the roughened surface should be thoroughly cleaned of loose particles and should be saturated with water for several hours before placing new concrete. The area surrounding the patch should be wetted also. The accompanying illustrations show correct and incorrect methods of patching.

Roughened Floors

Floors that have been improperly constructed may become roughened under service, or pitting may occur due to heavy impacts. Often such floors may be put into satisfactory condition by grinding off the roughened surface and will give good service for many years. On the other hand, if the concrete is of such poor quality that the surface will soon become roughened or pitted again, it would be more economical to resurface it with the proper quality of concrete.

Attaching Equipment to Floors

Theater seats, machinery and other equipment may be rigidly fastened to concrete floors with expansion bolts. For satisfactory results the concrete must be of such quality that it will resist the stresses developed by the equipment to be attached. The wearing course should be constructed as recommended previously. If large bolts extending into the base course are used, the base course should be well proportioned with not over 6 gal. of water per sack of cement to provide a good grade of concrete.

The usual procedure is to mark the location of bolts on the floor after it has hardened and cured, then drill the holes to the proper depth for insertion of the expansion shells.

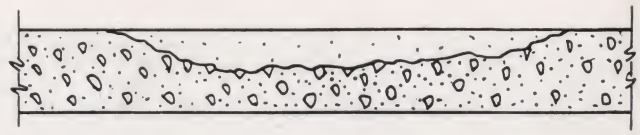
Maintaining and Cleaning Floors

Properly constructed concrete floors will require little maintenance other than cleaning. Periodic cleaning is essential to durability, as grit and dirt on floors subjected to considerable traffic will be ground into the finish and accelerate the rate of wear.

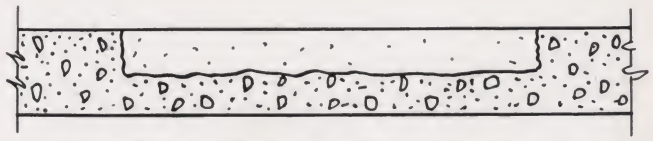
Floors subjected to spilled milk, syrups, fruit juices, brines, fats and oils and many other industrial products should be thoroughly scrubbed frequently. In many plants it is necessary to scrub the floors at least once a day. Warm, soapy water and stiff brushes should be used, after which the floor should be mopped clean. Electric scrubbing machines are widely used for cleaning large floor areas.

Surfaces subjected to heavy trucking should not be allowed to accumulate a crust of dirt, as sometimes happens in molasses, sugar and oil warehouses. Trucks ride unevenly over these obstructions, imposing undue impact stresses on the floor finish and increasing the tractive effort of the trucks.

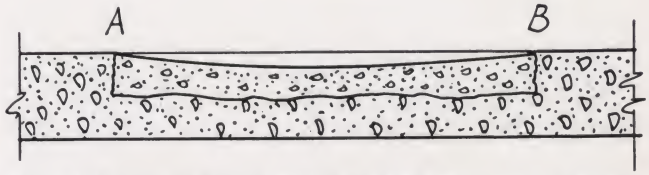
Garage and powerhouse floors frequently become soiled



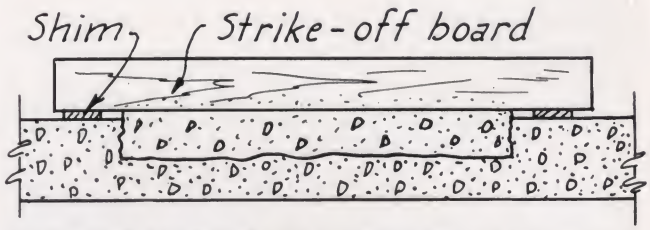
INCORRECTLY INSTALLED PATCH—Patches installed with feathered edges will soon break down under trucking.



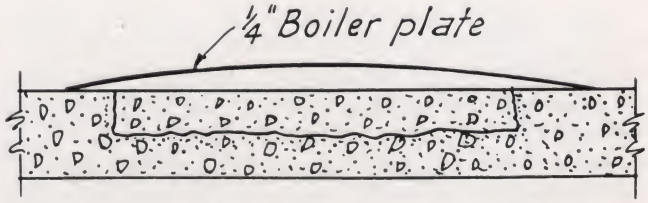
CORRECTLY INSTALLED FLOOR PATCH—The chipped-out area should be at least 1 in. in depth with the edges perpendicular.



RESULTS OF INCORRECT SCREEDING OF PATCH—When a patch is originally struck off to the level of the floor, the concrete will sag in the center, due to the fact that the straightedge has a tendency to cut off slightly below its lower edge and to the fact that the concrete shrinks during hardening. Additional concrete placed in the concave area will soon chip out under traffic.



CORRECT METHOD OF SCREEDING PATCH—The strike-off board is held slightly above the level of the floor by strips or shims laid the length of the patch on two sides. For large patches the thickness of these strips will be greater than for small patches. The concrete is allowed to rest for 1 to 2 hours. This allows the concrete to attain some of its initial shrinkage before being troweled to its final plane and will result in a uniformly level surface, plane with the rest of the floor.



PROTECTION OF PATCHES—Patches should be kept continuously wet and protected from traffic during the curing period. An economical method of protection consists in using a piece of ¼-in. steel sheeting bent as shown and placed over the patch to take traffic during the curing and hardening period.

with oil. Usually the oil has no detrimental effect if the concrete is properly made, but its presence detracts from the appearance and makes the surface dangerously slippery. Such floors may be cleaned by scraping off thickened oil crusts, then scrubbing with gasoline, taking due precaution against fire. The floor should then be thoroughly scrubbed with warm, soapy water and mopped. The treatment will not remove stains but will remove the objectionable coating of oil and grease. Special solvents are also available for removal of oil and grease.

Decorative floors should be cleaned with warm, soapy water prior to use and at subsequent intervals depending on the severity of service. Only mild soaps should be used on terrazzo and other types of decorative floors. Soap should be removed by rinsing thoroughly to prevent the surface from becoming slippery.

Terrazzo floors acquire a beautiful natural sheen when they are washed often for the first 2 or 3 months. After this period less work will be required in their upkeep.

Surface Treatments

The durability of concrete floors depends primarily upon observance of the fundamental rules in making, placing, curing and finishing the concrete. Dusting of the floor surface may occur if these rules are violated.

Many of these floors may be improved by applying some material to assist in hardening and binding the surface. These treatments are not cure-alls for poor materials or careless workmanship and will not make a perfect wearing surface of a poorly built floor. Magnesium fluosilicate, zinc fluosilicate, sodium silicate, aluminum sulphate, zinc sulphate, Chinawood and linseed oil and various gums, resins and paraffins are substances used for this purpose. Sometimes paints are applied after these treatments as further protection.

It is essential that the floor be clean and free from plaster, oil, paint or other foreign substances before giving any further treatment. It should also be fairly dry to assist penetration. When paint of any kind is to be used, it is important that the concrete be absolutely dry.

Fluosilicate Treatment

The fluosilicates of zinc and magnesium dissolved in water have been used with good success. Either of the fluosilicates may be used separately, but a mixture of 20 per cent zinc and 80 per cent magnesium appears to give the best results. In making up the solutions, ½ lb. of the fluosilicate should be dissolved in 1 gal. of water for the first application and 2 lb. to each gallon for subsequent applications. The solution may be mopped on or applied with a sprinkling can and then spread evenly with mops. Two or more applications should be given, allowing the surface to dry between applications. About 3 or 4 hours are generally required for absorption, reaction and drying. Care should be taken to mop the floor with water shortly after the last application has dried to remove incrusted salts, otherwise white stains may be formed.

Sodium Silicate Treatment

Commercial sodium silicate is about a 40 per cent solution. It is viscous and requires thinning with water before it will penetrate concrete. A good solution consists of 3 gal. of water to each gallon of silicate. Two or three coats should be used, allowing each coat to dry thoroughly before the next one is applied. Scrubbing each coat with stiff fiber brushes or scrubbing machines and water will assist penetration of the succeeding application.

Aluminum Sulphate Treatment

This treatment consists of one or more applications of solutions of aluminum sulphate. The solution is made in a wooden barrel or stoneware vessel and the water should be acidulated with not more than 1 teaspoonful of commercial sulphuric acid for each gallon of water. The sulphate does not readily dissolve and requires occasional stirring for a few days until the solution is complete. About 2½ lb. of the powdered sulphate will be required for each gallon of water. For the first treatment the solution may be diluted with twice its volume of water. Twenty-four hours after this application the stronger solution may be used, and 24 hours should elapse between subsequent applications.

Zinc Sulphate Treatment

This treatment consists of the application of a solution containing 1½ lb. of zinc sulphate and a teaspoonful of commercial sulphuric acid to each gallon of water. The mixture is applied in two coats, the second coat applied 4 hours after the first. The surface should be scrubbed with hot water and mopped dry just before the application of the second coat. This treatment gives the floor a darker appearance.

Oil Treatment

Chinawood, linseed or soybean oil may be diluted with gasoline, naphtha or turpentine and applied with mops or large brushes. About equal parts of oil and thinner give a good mixture for this purpose and often a single application is sufficient. In some cases the oil treatment may be repeated to advantage at semi-annual intervals.

Coverage

The amounts of the above solutions required to treat floors will vary considerably with the porosity of the concrete. Generally, a gallon of any one of the solutions will be required for each application on 150 to 200 sq.ft. of floor surface.

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CONCRETE FLOOR IN SOLID RED COLOR
St. Mark's Episcopal Church in Buffalo, N. Y. has a concrete floor with red pigment mixed in the finish. The aisle is scored in large squares.

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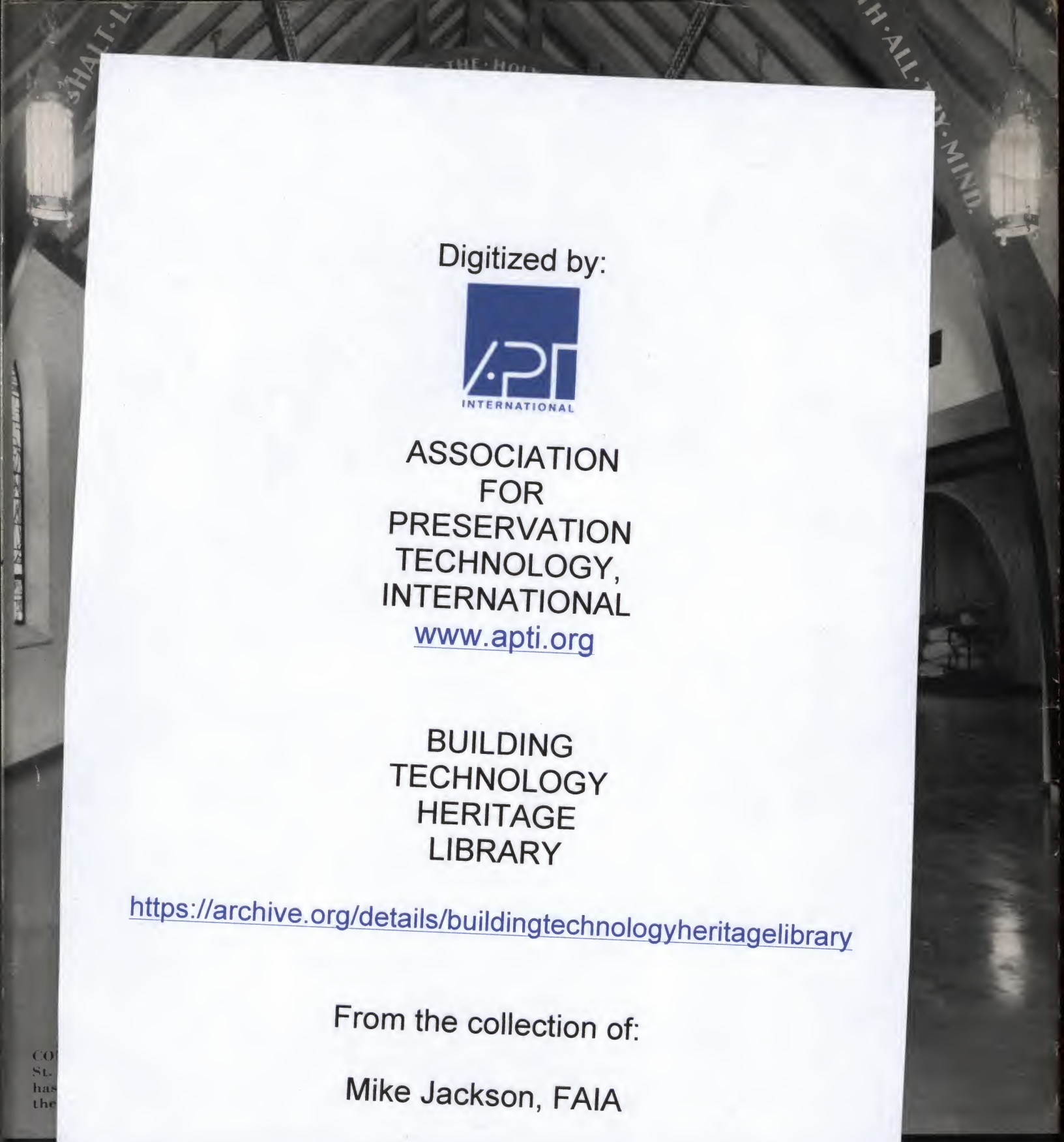

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